VOL. XLVIII, NUMBER 4 WHOLE NUMBER 409

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED BI-MONTHLY
(*Six numbers per year*)

July-August, 1954

PRINTED FOR THE SOCIETY

TORONTO: 13 ROSS ST.

The Royal Astronomical Society of Canada

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PRINTED IN CANADA

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VOL. XLVIII NO. 4 JULY-AUGUST, 1954 WHOLE NO. 409

WHERE TO DRAW THE LINE

USING THE STARS TO LOCATE THE NORTHERN BOUNDARY OF CANADA'S WESTERN PROVINCES

BY WARREN D. FORRESTER*

As I commence to write this article I recall my early school days and my first contact with the study of geography. How marvelously simple and exact each new fact that was absorbed seemed to be. Countries consisted of a capital city and a main export; the Trade Winds were designed to blow coffee across the ocean; and the Gulf Stream was installed to heat the British Isles. Boundary lines, too, were quite straightforward articles; all that was required to make them was a pencil, and, if you were really fussy, a straight-edge. Undoubtedly I should have been surprised had I then known that many of the boundary lines so boldly printed in our atlases had no existence other than on paper; however, I could scarcely have realized that by helping to fill in these gaps I would one day earn my bread and butter. Nevertheless that is what has happened. As an astronomer with the Geodetic Survey of Canada, locating the northern boundaries of the Prairie Provinces and British Columbia has been one of the jobs that has more or less justified my existence.

It was Canada's recent rapid development northwards that speeded the decision to complete the surveying of these boundaries. Until 1950 only small sections of the northern boundaries of Alberta and British Columbia had been dealt with at all, but commencing in January of that year a programme was launched jointly by the Federal and Provincial governments which has now brought the Alberta and British Columbia boundaries nearly to completion and made a good start on the Saskatchewan boundary. That stars have been able to play a part in this

*Geodetic Survey of Canada.

task was due to the boundary having been agreed upon as the astronomically determined sixtieth parallel of north latitude between certain east and west limits.

The adopted procedure has been to carry out astronomic observations at twenty-five mile intervals along the boundary and to mark the sixtieth parallel with monuments at these observation sites. Other survey parties then link the astronomic monuments by continuous ground survey. The final boundary is marked on the ground by a swath cut fifteen or twenty feet wide through the bush, with monuments placed not more than three miles apart along its length. The task of establishing the astronomic control monuments along the boundaries fell to the astronomy section of the Geodetic Survey, and this article is to tell some of the story of that work.

The instructions to be followed at one of these stations seem routine enough. Forty pairs of stars must be observed with a meridian transit telescope according to the Horrebow-Talcott method, each pair giving one value of the latitude. The mean of the forty values must have a probable error of less than ten feet. Although longitude values are not essential at such sites, they are helpful in running the subsequent ground survey, and also in controlling aerial photography of the area. Accordingly, the times of meridian transit for about twenty stars must be observed to yield a longitude in error by no more than fifty feet. The meridian transit is shown in figure 1.

To carry out this same routine on station after station would seem a monotonous prospect indeed. However, to date, Mother Nature has always stepped in, or jumped in, to rescue us from boredom. The first section tackled was through the muskeg in northern Alberta. No lakes suitable for aircraft landings existed in this section, nor was cross-country travel over the muskeg convenient in summer. These considerations caused us to set out in January with bull-dozer and tractor train to make our way through the sixty-below temperatures of the northern woods (see figure 2).

To the best of our knowledge this particular type of observing had not been previously attempted in such extreme winter conditions; consequently, considerable thought was given to devising remedies for all foreseeable difficulties. The moving parts of all the instruments were cleaned and lubricated with special winter oils and greases, after which the instruments were tested in the cold chambers of the National Research Council. One obvious difficulty would be the fact that although no heat might be allowed in the observing tent because of refraction, the batteries, clocks, and recording apparatus would not function properly

FIG. 1—The meridian transit. FIG. 2—Bull-dozer and tractor train. FIG. 3—Rescuing the bull-dozer from partly frozen bog. FIG. 4—Dog team.

in the cold. To solve this problem, a set of field telephones was secured to permit the observer outside to communicate with his assistant who was attending the records inside one of the heated cabooses of the tractor train. The observer's telephone was equipped with earphones and throat microphone to leave his hands free to work the transit. A little

bottle of alcohol was provided to clean frost off the telescope lenses and off the electrical contacts on the eye-piece micrometer drum; however, in practice, we found on some nights that the observer's breath froze on the instrument so frequently that the only solution would have been to have an observer who did not breathe. The fact that a human being does not function efficiently or comfortably in such cold was something that could not be circumvented. However, we did find this hardship to be much worse in anticipation than in realization, leading me to believe that some authors tend to exaggerate slightly on this point so as not to disappoint their readers.

Of all events experienced on this and on subsequent winter operations, perhaps the second most outstanding was having the bull-dozer sink into an only partly frozen bog. The most outstanding event was getting it back out again. Its rescue was achieved through the use of a large timber tripod, block and tackle, and two other bull-dozers (figure 3). Another bit of excitement was periodically provided by "snags", fallen trees or branches that catch underneath the cabooses and poke their way through the floor as the train moves over them. One such unwelcome hitch-hiker poked its head through the kitchen caboose floor, took the bench from under the cook, went through the pantry partition, and on out the far wall. The cook thought he had spotted the world's fastest growing tree.

A second winter was spent in tractor trains along the Alberta boundary, and it was during this winter that we discovered our ability to walk up and down the walls of the cabooses. This was achieved after the caboose had tipped over on its side while travelling over the rough frozen muskeg. The cabooses used the second year were more easily upset than those used the first year, having been made narrower so that they could pass along a smaller path through the bush. Actually, only two upsets occurred, and in each case less than two hours were taken to set matters right and upright. In the two tractor train operations a total of ten stations was established, covering about two hundred miles of border.

Two stations in northern British Columbia were established in a further winter operation in 1952, but these were reached by aircraft and dog team instead of by tractor train. The change in method of transport was convenient, because here lakes suitable for ski-plane landings existed within ten miles of each site, so that the dogs did not have very far to move the equipment and supplies (figure 4). Dog team travel for great distances might not have been quite as practicable, since before the dogs can be put to work, a trail must be packed down by snow-shoes. This means that a person must walk twenty miles to pack down a trail

and ten miles behind the dog team again to achieve a total of ten miles progress. However, for the short distances we had to travel, it was a pleasantly different and exhilarating experience.

Other stations have been established during the summer months wherever possible, but even in summer the type of transport used is far from uniform. Into British Columbia the Geodetic Survey has sent boundary parties by pack-horse, by aircraft, and by river barge. Only in Saskatchewan have conditions been such as to allow a fairly routine approach along the full length of the boundary. Lakes are abundantly sprinkled throughout this area, and last summer nine astronomic stations were established through the exclusive use of pontoon-equipped aircraft.

As the picture stands today, we see the astronomic control completed along the northern British Columbia and Alberta boundaries, and along three quarters of the Saskatchewan boundary. The cutting and marking has been completed from twenty-five miles west of the Liard River in British Columbia eastward to the Slave River in Alberta. I should not care to estimate how distant is the time that this work will be completed from the northern portion of the Alaska Panhandle to Hudson Bay, but at the present rate of progress it should not be far away. The very fact that such a survey has become necessary is an encouraging indication of the growing importance of Canada's northland.

I hope that this article has succeeded in illustrating a type of astronomic pursuit which may not have been too familiar to you previously. If so, you will not ask me the same question as was asked by an old prospector in Uranium City, Saskatchewan, namely, "What ya lookin' at them stars fer? There's still plenty uranium right here on the ground."

SWARTHMORE CONFERENCE ON ASTRONOMICAL RESEARCH IN COLLEGES

By Ruth J. Northcott

A conference was held at Swarthmore College, Swarthmore, Penna., on April 19 – 21, 1954, to discuss the problem of research for astronomers in small departments in colleges. Almost thirty astronomers attended from a wide variety of educational institutions scattered over the United States; Canada was represented by Dr. Helen S. Hogg of the University of Toronto. The assistant editor of the Journal was invited to attend. The conference was sponsored jointly by Swarthmore College and the National Science Foundation.

The conference was held at Sproul Observatory, on the beautiful Swarthmore campus, brilliant with springtime blossoms. The chairman was Dr. Peter van de Kamp, director of the Sproul Observatory. The steering committee consisted of the chairman and the following:

Dr. Edwin F. Carpenter, University of Arizona, Tuscon, Ariz.
Dr. Warren K. Green, Amherst College, Amherst, Mass.
Rev. Francis J. Heyden, S. J., Georgetown University, Washington, D.C.
Dr. Sarah J. Hill, Wellesley College, Wellesley, Mass.
Dr. J. J. Nassau, Case Institute of Technology, Cleveland, Ohio.
Dr. Carl K. Seyfert, Vanderbilt University, Nashville, Tenn.
Dr. Robert I. Wolff, College of the City of New York, New York, N.Y.
Dr. Stanley P. Wyatt, University of Illinois, Urbana, Ill.
Dr. Raymond J. Seeger, National Science Foundation, Washington, D.C.

The theme of the three-day conference was a discussion of methods by which astronomical research could be promoted in small departments. In such departments there may be only one instructor who usually has a heavy teaching load (often including allied subjects like physics and mathematics) and administrative duties as well, all of which reduce his time and energy available for research. It was agreed that astronomy can best be taught by an astronomer (instead of a mathematician or physicist) and that it is essential that he be enthusiastic and able to teach the most recent developments. This he can do more readily if he is doing research himself and having contact with other workers. It is obvious that an increase in staff is the solution to this problem, and the National Science Foundation can help to accomplish this. By giving research grants to these colleges for a period of three or more years, a second instructor can take part of the teaching duties and the two instructors can spend about half time on research.

Considerable discussion centred about the kind of research that

can be done where there are only small telescopes. The larger institutions have always co-operated with one another and been hosts to visiting astronomers, and as a result of this conference still greater co-operation is planned. An astronomer with small equipment may use existing material from a large observatory to do valuable work at his own institution; he may have the use of a larger telescope to take the photographs he requires for his programme, either during the summer or by taking leave of absence during the teaching year; he may do computational problems possibly in collaboration with others. Astronomers on this continent are indeed a friendly group who meet at least twice a year, with smaller "Neighbourhood" groups meeting more frequently. The discussions at such meetings are very stimulating and rewarding. It was evident from the discussion that there was great enthusiasm for co-operation, and that no astronomer need be "intellectually isolated".

As a step towards improving the co-operation between institutions the meeting adopted a suggestion of Dr. Nassau. This was that a list be made of about fifty observatories, giving information concerning the equipment and plate material available to other workers. Dr. van de Kamp was named chairman of the committee to gather this information. This should prove invaluable to all astronomers.

The National Science Foundation is anxious to support research and education in astronomy. The policy of the Foundation was described by Dr. Raymond J. Seeger. Research projects, in being submitted to the N.S.F. for support, should be described in sufficient detail that the committee passing on the grants can immediately make a decision, even if the programme is to have a duration of five years. It was pointed out that auxiliary equipment for research may be purchased from N.S.F. grants; new telescopes and the renovation or moving of an established telescope are also acceptable uses for N.S.F. funds.

An excellent example of the growing public interest in astronomy was brought before the conferees by the expanding facilities of the Spitz Laboratories. The group was transported by bus to Elkton, Maryland, where we were guests of Mr. Armand Spitz for dinner and were afterwards shown the new "living-room" model of the planetarium, the model A in operation, and the large model B, just ready to be shipped to Montevideo, Uruguay.

Those attending the conference felt that a discussion of the problems had resulted in a real stimulus to their solution. The spirit of co-operation which was so much in evidence throughout the sessions, along with the munificent attitude of the N.S.F., will go a long way towards increasing the efficiency and happiness of the astronomers of the continent who are engaged in both teaching and research.

VARIATIONS OF THE DAILY LEVEL OF THE 10.7-CENTIMETRE SOLAR EMISSION

By A. E. Covington and W. J. Medd

Abstract

The daily level of the solar radio flux at a wave-length of 10.7 centimetres consists of a slowly varying component associated with the appearance of sun-spots and a basic minimum level originating from the undisturbed solar surface. For the period 1947-1953 both components show a decline which has been associated with the decline of the sun-spot cycle.

Daily observations of 10.7-centimetre solar radio emission are made in Ottawa at the National Research Council and now extend over the past seven years.[1, 2] Since the series started in 1947 at the last peak of solar activity and continued into the current minimum, various degrees of solar activity ranging from high to low are now available for study. Inspection of the radio and optical solar data shows immediately that the intensity of the radio waves has declined and that the decline can be associated readily with the diminishing sun-spot activity.

The radio-telescope and radiometer were first put into operation on July 26, 1946, when a large sun-spot group was centrally located. Subsequent observations showed that the daily level of the radio emission decreased by a factor of two when this group disappeared on the western limb. These observations were of an exploratory nature and certainly showed that this important region of solar activity was radio-emissive at centimetre wave-lengths. Soon afterward important modifications were made to the equipment so that the initial observations are not to be placed on the same scale as the subsequent observations. These commenced a day before the partial eclipse of November 23, 1946.[3] Shortly after the eclipse the receiving pattern of the antenna was measured and found to be satisfactory. Commencing in February 1947 routine observations on a daily basis were made, and have since been maintained without serious interruptions.[4, 5] The radio-telescope has been in continuous use with periodic checks of important parameters. Although the radiometer was replaced in 1951, the original design was duplicated[6] in order to avoid the possibility of introducing a systematic error. The maintenance of the equipment has been performed with the intention of keeping the operating conditions the same.

The cone of acceptance of the four-foot reflector is about seven degrees to the half power points, so that the whole radiation from the solar disk is received. Except for infrequent outbursts of radio emission which are associated with the appearance of a solar flare, the level of

emission throughout a day has been found to remain relatively constant and as a matter of convenience only one calibration need be made each day. This is usually done about 10:00 E.S.T. The effect of a burst of radiation is not considered in arriving at the daily level. This level of radio emission is measured as an equivalent temperature of the antenna radiation resistance with the antenna pointing toward the sun, and then converted into units of flux ($100°K. = 0.43 \times 10^{-20}$ watts/m.^{2}/c.p.s. bandwidth for two polarizations).

The daily values for the particular year 1951 have been plotted in the upper curve of figure 1. The characteristic feature of this curve is a

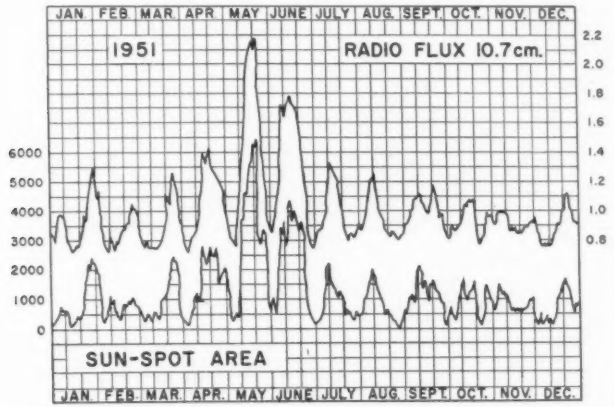

FIG. 1—*Upper curve*: daily values of solar radio flux at wave-length of 10.7 cm.; *lower curve*: daily values of sun-spot area in millionths of sun's disk (U.S. Naval Observatory).

periodic increase and decrease superimposed upon a fairly definite base-line. The period of the irregular curve, 27–28 days, corresponds to that of the solar rotation. The periodic increase may be explained in terms of discrete radio-emissive regions or radio spots, which radiate more intensely than the general solar background, and which are carried in and out of view by solar rotation. Thus the nature of this curve suggests the possibility of two different types of solar noise—a fluctuating component and a steady one. However, without knowing the physical characteristics of the radio emissive regions the exact separation of these components will be difficult. Even so, the radio data for each year will provide certain characteristic maximum, minimum and mean values, which may be useful in themselves as annual indices of the solar activity.

The long-term variations in solar activity as revealed by the radio data alone are seen readily from a graph in which only the maximum and minimum values of the 27-day wave have been recorded, and the gradual changes between these extreme values approximated by a continuous line (figure 2). Such a plot allows the essential points of the data to be

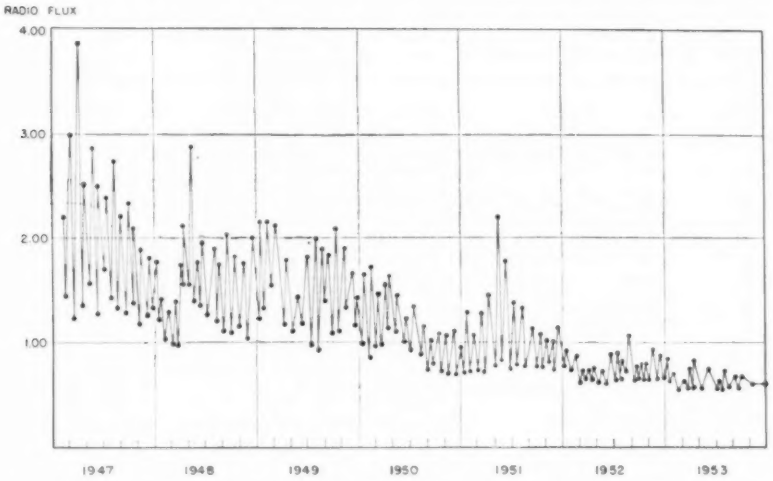

FIG. 2.–Maximum and minimum values of 27-day fluctuation of 10.7-cm. radio flux.

shown with a great compression of the time scale. A decline in the maximum and minimum values of the 27-day fluctuation for the seven years, 1947–1953, is very evident. Numerical details for the mean, the high, and the low values for each year are given in Table I.

In the optical region, solar activity is manifested by the appearance of sun-spots, plages, prominences, regions of coronal activity and other special features. This diverse activity is difficult to measure and at present much-used indices of solar activity consist of the number of sun-spots on the disk or the area of these sun-spots. These measures show short-term variations of a few days duration which have been related to various aspects of the growth and decay of activity, and a more regular trend recurring every 27 days which is related to the rotation of the sun. One long-term variation exists over several years and is the well known eleven-year cycle of solar activity. The various features of solar activity in the optical regions are themselves interrelated in a complex manner and may correlate one with another. Thus in a preliminary survey of the

TABLE I

	1947	1948	1949	1950	1951	1952	1953
Number of Daily Solar Noise Observations	260	320	320	266	274	300	288
Recurrence Period—days	26	27–28	27	26–27	28	28	27
Days with Simultaneous Radio and Optical Observations	254	315	312	262	268	288	283
Peak Solar Flux	3.87	2.86	2.17	1.74	2.17	1.05	0.89
Date	Apr. 7	May 10	Jan. 17	Feb. 20	May 21	Aug. 28	Jan. 14
Minimum Solar Flux	1.16	0.99	0.95	0.69	0.71	0.60	0.55
Date	Nov. 7, 10	Mar. 5, 23, 24	Aug. 9, 11	Dec. 22	Jan. 15, Apr. 4	Feb. 29, May 12, June 6, 8, 11	July 26
Mean Solar Flux	1.89	1.50	1.51	1.10	1.03	0.74	0.64
Peak Sun-spot Area	7736	6646	5088	5187	6471	2099	1575
Date	Mar. 7	May 11	Jan. 18	Feb. 15	May 21	Aug. 27	Apr. 30
Minimum Sun-spot Area	332	36	266	6	0	0	0
Date	Mar. 19	Mar. 22	Aug. 11	Dec. 22	Aug. 29	15 days	103 days
Mean Sun-spot Area	2709	2050	2200	1343	1263	468	184
Correlation Coefficient	0.85	0.87	0.83	0.85	0.95	0.82	0.77
Slope $\left(\frac{\text{Flux}}{\text{Area}} \times 10^{-4}\right)$ K	2.60	2.46	2.13	2.07	2.39	1.81	1.55
Intercept (Flux) F_0	1.18	0.99	1.05	0.82	0.73	0.65	0.61
Intercept in Equivalent Temperature of Spotless Sun ($\times 10^{-4}$) $^\circ$K.	7.26	6.10	6.43	5.06	4.47	4.00	3.72

NOTE: Solar flux in this table, and also on the various graphs, is given in units of 10^{-20} watts/m.^{2}/c.p.s. for two polarizations. Sun-spot area in millionths of solar hemisphere.

origin of the fluctuating part of the solar radio noise, it may be assumed that any one of the conspicuous optical surface features may be related to the mechanism which gives rise to the radio-emissive regions. This association between radio and optical phenomena can be sought for by means of correlation studies. In addition to the primary solar indices, secondary indices such as the magnitude of the diurnal variation of the earth's magnetic field offer further study.

The solar index based upon the area of sun-spots has been successfully correlated with the 10.7-centimetre solar flux. The use of this well established and readily available index was first suggested by the results of a solar eclipse which showed that a bright radio spot was associated with an optical sun-spot group.[3]

The total daily sun-spot area as measured by the Naval Observatory in Washington and corrected for foreshortening,[7] has been plotted alongside the daily radio data (figure 1). A displaced set of co-ordinates has been used in order to demonstrate the correspondence existing between the two series of solar observations. It is immediately apparent that the two curves follow the same excursions, increasing and decreasing together. However, there is one particular difference in that although the minimum values occur simultaneously, the sun-spot area decreases to zero while the radio flux fails (as previously noted) to do so. There is thus an indication of two components of radio noise: a basic one which alone is present when the sun is free from discrete radio-emissive regions, and a second one which is superimposed upon the first and is related to the presence of sun-spots. The first component has been called "the quiet sun emission" or "basic radio emission"; while the second component has been called "the slowly varying component". The radio noise generally increases with the appearance of sun-spots and indicates that the radio-emitting surfaces associated with the sun-spots are at a considerably higher temperature than the background.

Even in years of maximum sun-spottedness, certain days occur when the sun-spot area on the visible disk is very low. For example, in 1947, at the time of peak sun-spot areas, the area reached a peak value of 7800 millionths on March 7th, and twelve days later, when the main sun-spot group had been carried out of view, dropped to a value of 332 millionths. The radio emission varied in the same sense and showed a large change; the flux intensity decreasing from 2.75 on March 7th to 1.23 units on March 19th. This shows that the principal regions of radio emission and the appearance of sun-spots were confined to the same hemisphere, and by tracing the 27-day recurrence points, it is seen that these regions existed for several rotations. The other hemisphere which

lacked any great activity likewise traced out a lower envelope which may be regarded as an approach to the spotless sun. The emission from the radio spots alone is thus approximated as the excess above the lower envelope. Thus both the spotless sun component and the slowly varying component, as interpreted in figure 2, show a decline from 1947 to 1953. This same decline is illustrated in a different manner by plotting for each year the mean radio flux, which consists of the slowly varying and basic solar components; the minimum flux, which approximates the basic component; and the mean sun-spot area obtained from the Naval Observatory (see figure 3). For the period considered all of these measures show a decline.

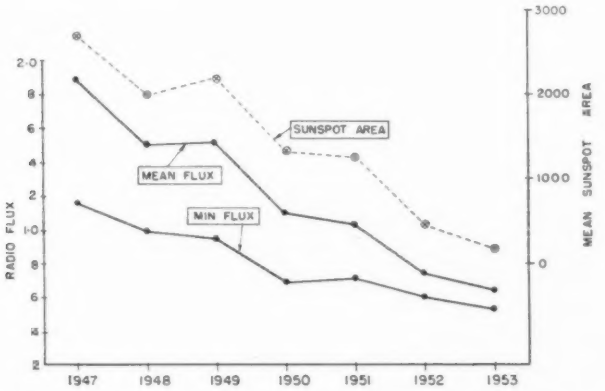

FIG. 3—Annual mean values of sun-spot area, mean radio flux, and minimum flux.

The manner in which the solar noise is related to the sun-spot area can be examined further by postulating a mathematical relationship between the two. The assumption that the radio flux is proportional to the area of a sun-spot regardless of its position on the solar disk is expressed by the linear equation: $f_s = Ka$ (Eq. 1), where f_s is the radio flux from the sun-spot, and a is the hemisphere area of the sun-spot. The constant K is the radio emission from unit surface of the radio sun-spot and will depend upon the manner in which the radio emitting surface is related to the underlying optical sun-spot. Since spots appear at any longitude on the disk, the total spot emission is the sum of the terms of Eq. (1). To this is added the background emission from the solar disk, F_0, so that the final equation to apply to the observational data has the form $F = KA + F_0$ (Eq. 2), where F is the total radio flux and A is the total

sun-spot area. The constant F_0 is the intercept for zero sun-spot area, and is independent of the manner in which the radio emitting surface is related to the area of the sun-spot.

This mathematical relationship can be derived approximately from a simple model of the radio sun-spot which assumes that the radio emission radiates from a sphere placed over the optical sun-spot. Such a representation is shown in figure 4, in which the diameter of the sphere is

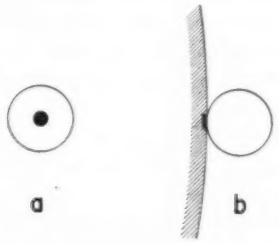

FIG. 4—Model of radio-emissive region: (a) on central meridian, (b) on limb.

five times larger than the size of the underlying sun-spot. It can be seen that the area projected towards the earth changes only when the spot is past the limb; otherwise it will be related to the true area of the underlying sun-spot. The factor relating the size of the optical spot to the diameter of the radio spot is contained in the constant K. Details of such spot models are given in papers by Denisse, Waldmeier and Mueller, and Piddington.[8, 9, 10]

The observational data for the year 1951 have been plotted on a scatter diagram—daily values of radio flux versus sun-spot area corrected for foreshortening—and are shown in figure 5. The straight lines which best fit the data are shown in the graph; the solid line is based upon the assumption that all the errors lie in the radio flux, while for the dashed line it is assumed that all the errors lie in the sun-spot area. The constants F_0 and K have been calculated (with errors assigned to the radio flux data) for each of the seven years, 1947–1953, and are listed in Table I.

The value of the correlation coefficient, r, between the radio flux and sun-spot area for the seven-year period is 0.85. The number of observations to use in the evaluation of the probable error is difficult to determine since the sun-spot area changes gradually from day to day, and the daily measures on successive days are not completely independent.[11] Over a period of a year solar conditions will have changed considerably so that the individual values of r found for each year may be taken as indicative

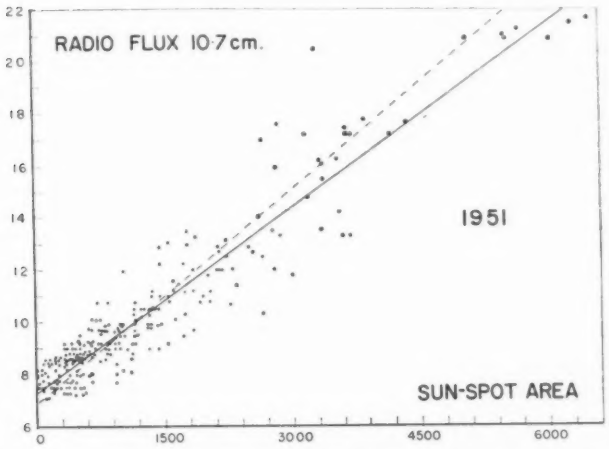

FIG. 5—Scatter diagram of daily values of 10.7-cm. radio flux and sun-spot area.

of a scatter around the true value of r. These annual values are consistently high, in the range 0.76 to 0.95, and show that the simple linear relationship between radio flux and sun-spot area has some meaning.

These values of the correlation coefficient can be interpreted in other terms by saying that approximately 75 per cent. of the variation has been explained by the assumed relationship between sun-spot area and radio flux; leaving a residue of 25 per cent. still to be explained. When other indices of similar nature are used, such as the Zurich relative sun-spot number, the correlation, as might be expected, is not substantially altered. This departure of the correlation coefficient from unity may be caused by other variables which have not been considered, as well as by the random errors which are present in both series of observations. One such variable may be the plage measures which are more indicative of a centre of solar activity than the appearance of sun-spots shown in total light. This was verified when a highly directive antenna showed a radio-emissive region associated with a calcium plage which did not contain any sun-spots.[12, 13] In the present analysis the emission from this type of radio spot will appear in what has been termed the quiet sun component, thereby giving too large a value for the flux from the undisturbed solar background. Only a few records have been examined so no definite answer can be given as to the frequency of occurrence over a long period of time.

It is well known that the sun-spots are seats of large magnetic fields which extend upwards into the solar atmosphere. These fields have been

shown to influence the radio emission.[14] Their possible influence had been considered by Denisse[15] by the introduction of a new solar index in the form $\sum \sqrt{A}\ H$, where A is the area of a spot whose maximum magnetic field is H.

In addition to the lack of correlation due to the omission of other variables, a very simple model has been used with a particular foreshortening factor for all sun-spots regardless of their size or stage of development. Some of these details have been considered by Denisse[8] who used one foreshortening factor for the large spots and another one for the small spots. Since only a slight improvement was noticed, these refinements to the model have not been employed.

The constant F_0 gives the flux from the solar disk when the sun-spot area is extrapolated to zero, while the constant K gives the flux from unit area of the radio sun-spot. The annual values for the years 1947–1953 are shown in figure 6. The plot for K is shown in the upper graph. Although there is considerable scatter there appears to be a trend towards a cooler radio spot for the years of low sun-spot area. The points representing the emission from the spotless sun, F_0, show less scatter and indicate that the

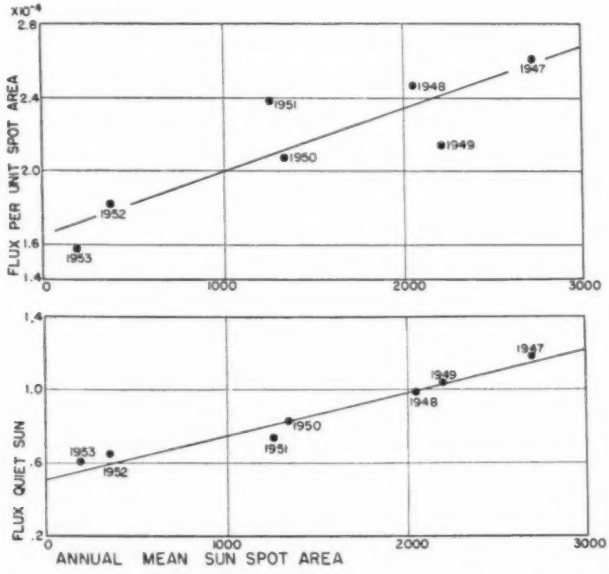

FIG. 6—*Upper curve*: annual values of radio emission per unit sun-spot area; *lower curve*: annual values of radio emission from spotless sun.

spotless radio sun has reduced in output by a factor of two from 1947 to 1953. This suggests that the sun may be regarded as a variable star.

A variation of the radio emission from the quiet sun in synchronism with the sun-spot cycle was suggested by van de Hulst in 1949[16] after he had shown that the electron density in the solar corona changes by a factor of 1.8 during the eleven-year sun-spot cycle. The analysis of the emission and absorption of radio waves from layers of the solar atmosphere at different temperatures and densities over the band of wave-lengths open for observation (1 to 600 centimetres) shows that the change in the quiet sun level due to the observed variation in electron density will be most pronounced in the decimetre region. This is the wave-length region in which the solar corona is partially transparent and there are comparable components from chromosphere and corona. At shorter wave-lengths this effect should not be observed since the corona is very transparent; nor should it be observed at longer wave-lengths for the opposite reason that the corona is already in full emission and any increase in opacity will have no effect.

The first observations of the solar radio emission on a wave-length of 10.0 centimetres were obtained by Southworth[17] at the Bell Telephone Laboratories in 1942. This was at a time of sun-spot minimum and an equivalent temperature of the sun of 18,000° K. was obtained. No day-to-day variations, indicative of emission from the vicinity of sun-spots, were noticed. When the first few months of the present series of observations were discussed,[4] the spotless sun was found to have an equivalent temperature of 79,000°K. (average temperature over an assumed solar disk of ½° diameter). In addition, a large slowly varying component was found to be associated with the appearance of sun-spots. This appeared out of line with Southworth's original work, but now that the solar activity is declining, with a corresponding decline in the radio flux, both from the quiet sun and the radio-emissive regions, the results are in closer agreement. The minimum value from the present series of measurements is 0.55×10^{-20} watts/m.^{2}/c.p.s., or an equivalent temperature of 34,000°K. An extrapolation of the straight line in figure 6 to zero sun-spot area indicates a value of 0.52×10^{-20} watts/m.^{2}/c.p.s. (32,000°K. equivalent temperature). In comparison with Southworth's result, the agreement is as close as may be expected when consideration is given to the magnitude of absolute errors that can exist in measurements of this kind. The higher value of equivalent solar temperature is substantially correct, since an independent measure made by Piddington[18] in 1948 is only 12 per cent. lower than the corresponding measure obtained from this series of observations for the period under consideration.

The existence of a systematic error introduced by the use of too high a sky temperature (50°K.) has been known for some time,[5] but no account of it was contemplated until the question was investigated further, and the antenna gain redetermined. These are the two parameters most likely to affect the accuracy of absolute measurements. The antenna gain is related to the effective area over which the radiation is collected, while the sky temperature is used as one calibration point in the experimental procedure for determining the emission from the sun. These experiments have now been completed; the results indicate that no change is necessary in the figure used for antenna gain, and that a value for sky temperature of 8°K. rather than 50°K. is of the correct order of magnitude. Thus an average correction can be made by multiplying all flux measurements by 1.18. The correction factor varies from 1.17 in summer to 1.19 in winter. This variation occurs since the second calibration point involves covering the antenna dipole with a radio black box which is at outside temperature: average +23°C. in summer and −9°C. in winter.

Within the past few years (1951, 1952) other observatories throughout the world have engaged in making daily observations of the solar radio flux in the decimetre wave-length region of the spectrum. Ultimately, it is hoped the radio sun will be watched continuously. These observations have been reported to the International Astronomical Union and are published in the *Quarterly Bulletin on Solar Activity*. The location and frequency of operation of the stations in operation in 1952 are shown in Table II. A graphical representation of the daily values

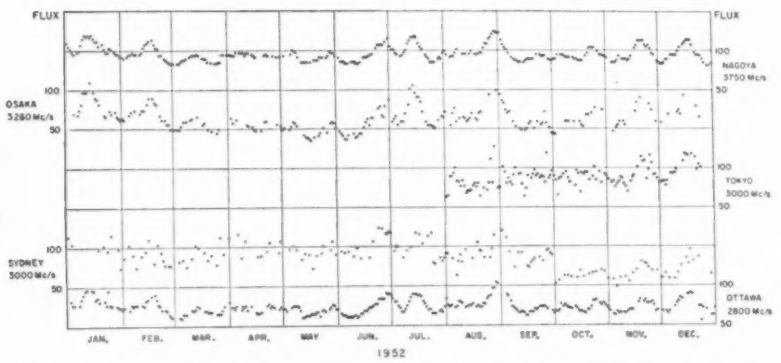

FIG. 7—Daily values of radio flux recorded for 1952 at five observatories. Flux units: 10^{-22} watts/m.^{2}/c.p.s.

TABLE II

RADIO OBSERVATIONS OF QUIET SUN ON NOVEMBER 4, 1952

Location	Frequency mc./sec.	Flux	Equivalent Temperature of Sun (° K.)
National Research Council Ottawa, Canada	2800	0.62A 0.75B	37,800 45,800
Radiophysics Laboratory Sydney, Australia	3000	0.55	29,200
Tokyo Astronomical Observatory Mitaka, Tokyo, Japan	3000	0.80	42,500
Radio Astronomical Observatory Osaka City University Osaka, Japan	3260	1.00	45,200
Research Institute of Atmospherics Nagoya University Toyokawa, Japan	3750	0.86	29,300

A based upon sky temperature of 50° K.
B based upon sky temperature of 8° K.

is shown in figure 7. Intercomparison of these curves shows that similar variations in the solar flux have been measured at all five stations. These variations have suggested that the magnitude of the daily values be analysed into two components—an emission from the discrete radio spots, and the emission from the undisturbed solar surface. The two components have been definitely separated for the year 1952 as an antenna with a narrow fan-shaped beam has been in operation in Ottawa and has determined the strength and location of the radio spots on the solar disk. Examination of the drift curves indicate that for certain periods there was a very small excess above the undisturbed surface, and that for practical purposes the sun was free from radio spots around May 12, June 7, September 14 and November 4. Thus the lower bound of the fluctuations shown in figure 7 represents the magnitude of the quiet sun emission. The reported values of flux from the Nagoya and Ottawa observatories for a particular minimum, November 4, are shown in Table II, while the values for the other stations were interpolated from a curve. The equivalent temperature of an assumed solar disk ½° diameter

(solid angle Ω) has been found from the equation: Flux $= \frac{2kT}{\lambda^2}\,\Omega$ where k is Boltzmann's constant, and λ is the observing wave-length. These equivalent temperatures for the quiet sun of November 4, 1952, based upon the measurements from the five observatories, are shown in Table II.

The scatter of the tabulated values for those stations operating on nearby frequencies is indicative of the systematic errors, while for the two stations, Nagoya and Ottawa operating at well separated frequencies, the tabulated values may include a spectral difference as well. Even though the absolute levels may not be known for these two stations, the internal errors must be very small since small changes in the slowly varying component (the fluctuations in daily level above the lower envelope) are present in detail in both series. In a radiometer system with a linear response which uses the temperature of the sky as a reference point for the daily calibration, any systematic error must appear as a multiplier for the daily level. This assumption allows the relative change in the spot component to be measured in terms of the flux from the solar background and for this purpose the systematic errors need not be known. Such a comparison shows that a spectral difference does exist in that the flux from the radio-emissive regions divided by the quiet sun level at 10.7 centimetres is 1.3 times as large as the same ratio at 8 centimetres.

We gratefully acknowledge the assistance of Mrs. Gladys Harvey in reducing the records and tabulating the results of this long-term undertaking; and that of the technical personnel, Messrs. W. A. G. Kennedy, K. Prior, and J. T. Winmill, who have aided in the construction and maintenance of the equipment.

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14. A. E. Covington, "Circularly Polarized Solar Radiation on 10.7 Centimetres", *Proc. I.R.E.*, vol. 37, p. 407, 1949.
15. J. F. Denisse, "Relation entre les Emission Radioélectriques Solaires Decimétriques et les Taches du Soleil", *Comptes Rendus*, vol. 228, p. 1571, 1949.
16. H. C. van de Hulst, "Brightness Variations of the Solar Corona", *Nature*, vol. 163, p. 24, 1949.
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VARIABLE STAR NOTES

American Association of Variable Star Observers

By MARGARET W. MAYALL, *Recorder*

The 43rd A.A.V.S.O. Spring Meeting was held in New York on May 7 and 8, 1954, as a part of the Columbia University Bicentennial celebration. Our host, Dr. Jan Schilt, Director of the Rutherford Observatory and head of the Department of Astronomy at Columbia University, gave a very delightful welcoming address, and told something of the history of astronomy at Columbia and the founding of the Rutherford Observatory. Columbia has been closely associated with the development of positional astronomy and computing machines.

Very appropriately, the feature lecture of the meeting was given by Dr. Wallace Eckert on the "Contributions of the Electronic Calculator to Astronomy." Dr. Eckert is Director of the I.B.M. Watson Laboratories at Columbia, and has long been associated with computing methods, both at Columbia University and as Director of the American Nautical Almanac Office. Dr. Eckert told of his early association with the A.A.V.S.O., and particularly with the well-known members, J. Ernest G. Yalden and Ernest W. Brown. He compared Prof. Brown's famous lunar tables, which represented a lifetime of work, with the new 20-year ephemeris of the moon just completed with the electronic calculator. He traced the development of calculating machines from Pascal's adding machine, built in 1642, to the present-day calculators. It took nearly 300 years for the desk calculator to come into general use, about 50 years for the punch card machine to be developed from the first model, and about 25 years after the discovery of the vacuum tube for us to get the electronic calculator. A significant comparison of the time saved in present day calculation is that a computation that would require a week's work with logarithm tables would require a day with a desk calculator, an hour with a punch card machine, a minute with an electronic calculator, and only one second with the latest sequence calculators.

Among other papers presented at the meeting was one by Miss Margaret Harwood, in which she told of her work at the Maria Mitchell Observatory on the "Variable Stars in the Scutum Cloud." When she started work on the field in the 1920's, few variables were known, but

now they number in the hundreds. Her work is done with photographs taken with the Maria Mitchell 7½-inch Cooke triplet at Nantucket, supplemented by plates from the Harvard College Observatory collection. She has extended her survey to variables around 15th magnitude at maximum.

Leith Holloway gave a statistical paper, entitled "Sun-spot Number Autocorrelations." He plans to make a similar study of some of the A.A.V.S.O. light curves of regular long periods and also of some of the semi-regular variables.

Clinton B. Ford told of his plans to study the polarization of sky light during the total eclipse of the sun, June 30, 1954. He also showed "A Remarkable Astronomical Photograph:" an authentic photograph taken of the Recorder making an observation with the Ford 10-inch reflector.

Harry L. Bondy, the editor of the Solar Division Bulletin, spoke on "Solar Activity 1944–1954, the Last Cycle," and also told of what we can expect to see at the coming eclipse of the sun.

Herbert A. Luft exhibited a sample of the new edition of the invaluable Bonner Durchmusterung star charts, which have been out of print for many years. The southern group of them, from the equator south to 23½ degrees, is now available, and it is expected that delivery will be made on the northern charts in a few months. Mr. Luft also had a copy of the new micro photographic edition of the B.D. catalogues: all four large volumes are now put into one small volume; nine pages of the original edition on one page of the new.

Richard S. Luce, a member of the Amateur Astronomers Association of New York, presented "A Study of the Amplification Ratio of the Barlow Lens with Varying Focal Length." Giuseppe DiDomenico spoke on "The Practical Application of the Planets' Movement Around the Sun."

Miss Dorrit Hoffleit could not be present, and her paper on "Periods 100 to 150 Days" was read by Mr. Witherell. Miss Hoffleit made a special study of the group of intrinsic variable stars whose periods fall between the recognized classical cepheids and the ordinary long period variables. They are divided into four classes: Mira, where the amplitude is more than 2½ magnitudes; long period, where the amplitude is less than 2½ magnitudes; RV Tauri, special type of semi-regular variation; and the semi-regular variables. A.A.V.S.O. light curves were available for 27 of these stars. Miss Hoffleit traced the light curves for a 1000-day interval for each of these stars and arranged them according to published type and period. At first sight, the arrays of curves suggest that some stars in each of the groups could equally well have been assigned to others. Additional epochs of many of the stars would show even more mixture

between the groups. Miss Hoffleit's main purpose in presenting the paper was to encourage the A.A.V.S.O. to continue its concentration on the so-called Long-Period and Semi-Regular variables whose periods lie between 100 and 150 days and whose amplitudes are under three magnitudes, so that eventually the mysteries of their physical behaviour and constitution may be solved. It is particularly important to concentrate on those whose periods now appear to be the most regular, for perhaps like SX Herculis they will suddenly surprise us by their apparently characteristic instability.

A feature of the meeting was the presentation of the Twelfth A.A.V.S.O. Merit Award to Mr. Percy W. Witherell. His citation reads: "The American Association of Variable Star Observers presents its Twelfth Merit Award to Percy W. Witherell in appreciation of his loyal and devoted service as Treasurer of the Association for nearly a quarter of a century and in recognition of his enthusiastic contributions to the advancement of interest in astronomy." The first Merit Award was given in 1934 to Leslie Peltier, the famous comet finder who has been contributing monthly variable star reports to the A.A.V.S.O. since 1918. Dr. Harlow Shapley, former director of the Harvard Observatory, received the tenth Merit Award, and others have been presented to outstanding members of the A.A.V.S.O. All of the awards have been individually designed and illuminated by Fred E. Jones. Mr. Jones was elected a Patron of the Association in appreciation of his beautiful work.

Mrs. Margaret W. Beardsley told of meeting A.A.V.S.O. members during a recent trip to India and Greece. Additional papers read by title were: "Paper Laps" by Robert M. Greenley; "George Ellery Hale and His Associates" by Ralph A. Wright; and "Report on Observations" by Mack Lee Felts.

Twenty-two new members of the A.A.V.S.O. were elected: the largest number elected at a meeting in several years. Our membership has a wide geographical distribution, and it is well shown by the addresses of our new members: Georgia, Wisconsin, New York, Massachusetts, Illinois, Ohio, Australia, Yugoslavia, New Jersey, Texas, California, Indiana, Montana, and South Africa.

The next meeting of the Association will be held at Brown University at the invitation of President Wriston and Prof. Smiley. The meeting will be on some week-end in October 1954, the date to be announced later.

Observations received during April and May, 1954: During April, 50 observers contributed 3,429 observations, and in May, 48 persons contributed 4,772.

	April		May			April		May	
	No. Var.	No. Ests.	No. Var.	No. Ests.		No. Var.	No. Ests.	No. Var.	No. Ests.
Abbey, L. B., Jr.	6	9	..	..	Kastin, Harold	46	251	47	181
Adams, Robert M.	55	125	65	150	Kelley, Leo A.	..	..	17	21
Alvarez, Hector	6	6	1	3	Kelly, Frank J.	14	14	10	10
Anderer, Joseph A.	..	..	2	2	de Kock, R. P.	..	..	131	860
Anderson, Curtis E.	83	150	55	75	Lonak, Eugene	4	8	1	9
Aronowitz, Charles	81	314	84	375	Maran, Stephen	57	89	72	167
Barber, W. F., Jr.	..	..	1	9	Mayall, M. W.	4	4	..	..
Beidler, Herbert B.	29	81	29	52	Mayall, R. N.	2	2	..	..
Bicknell, R. H.	6	12	13	77	McPherson, Chas.	7	7	..	..
Botham, John H.	..	..	17	41	Mebius, W. G.	8	9	..	..
Boutell, Hugh G. ..	5	7	..	..	Miller, William A.	19	32	18	35
Buckstaff, Ralph N.	11	19	8	10	Montague, Allen C.	15	20	36	53
Chandra, Radha G.	74	151	..	..	Oravec, Edward G.	124	487	119	430
Charles, Donald F.	..	..	8	8	O'Sullivan, W. H.	9	12	8	12
Cragg, Thomas A.	115	122	40	40	Overbeek, M. D.	..	..	55	247
Darsenius, Gunnar	45	155	30	151	Pearcy, Robert E.	..	..	5	5
Diedrich, DeLorne	3	4	2	4	Peltier, Leslie C.	52	139	21	56
Diedrich, George	8	12	2	7	Perry, Wendell L.	..	..	1	2
Elias, Demetrius P.	..	..	89	514	Renner, C. J.	98	126	..	..
Estremadoyro, V. A.	16	16	12	14	Rizzo, Patrick V.	61	74	39	77
Fernald, Cyrus F.	133	269	160	455	Robinson, James C.	7	7	..	..
Ficonetti, Rene	19	30	..	..	Rosebrugh, D. W.	15	98	14	46
Ford, Clinton B.	97	100	116	121	Royer, Ronald	19	49	18	20
Gaustad, John	9	9	6	6	Schorn, Ronald A.	5	14	..	..
Goodsell, J. G.	1	1	..	..	Spooner, John M.	1	4	3	6
Greenley, R. M.	15	15	..	..	Taboada, Domingo	95	110	24	24
Gross, Richard A.	..	..	4	7	Thomas, Morgan A.	11	29	5	5
Hartmann, F.	125	133	113	123	Venter, S. C.	..	..	64	192
Hein, George	..	..	5	9	Walsh, John F.	..	..	6	6
Hiett, Lancaster	5	11	..	..	Wells, Karl A.	1	1	3	6
Isaak, George	7	23	..	..	Wyckoff, Jerome	28	36	26	48
Johnsson, R. G.	21	27	1	1	Zimmerman, W. W.	6	6	..	..

Nova Search Programme: During the months of April and May 1954, reports were received from the following six observers. Listed for each observer is the month the observations were received, the areas observed (in italics), the number of nights the region was checked, and finally, the limiting magnitude.

DARSENIUS, GUNNAR, April—*Dome:* 2, 2; *16, 17:* 4, 6; May—*16, 17:* 1, 6; *16, 17:* 1, 5.
DIEDRICH, DELORNE, April—*Dome:* 2, 2; *94:* 5, 6; *94:* 1, 5; May—*Dome:* 2, 2; *94:* 2, 6; *94:* 2, 5.
DIEDRICH, GEORGE, April—*Dome:* 4, 2; *56:* 7, 6; May—*Dome:* 4, 2; *56:* 7, 6.
RICK, LOUIS, April—*Dome:* 5, 2; *18:* 1, 5; *18:* 2, 4; *18, 65:* 1, 3; *65:* 2, 5; *65:* 1, 4; May—*Dome:* 6, 2; *18:* 1, 2; *18, 63:* 2, 5.
ROSEBRUGH, DAVID W., April—*Dome:* 9, 3; *Dome:* 1, 2; *1, 34:* 7, 4; *1, 34:* 1, 3; May—*Dome:* 8, 3; *1:* 1, 4; *34:* 2, 4.
WELLS, KARL A., April—*Dome:* 1, 4; May—*1–22:* 10, 4.

A.A.V.S.O. Headquarters
4 Brattle Street
Cambridge 38, Massachusetts
May 1954

REVIEW OF PUBLICATIONS

Dialogue Concerning the Two Chief World Systems by Galileo Galilei, translated by Stillman Drake. Pages xxvii plus 495; 6¼ x 9½ in. Berkeley and Los Angeles, University of California Press, 1953. Price $10.00.

It is almost incredible that one of the greatest works in astronomy, the book which, more than any other, heralded the modern approach to science, should have been virtually unavailable in English translation for the past three hundred years. Galileo's famous *Dialogo* appeared in Italian in 1632. In 1661 Thomas Salusbury translated it into English, and five years later most of the copies of this English edition were destroyed in the great fire of London. Until now, although German and modern Italian editions have appeared, there has been no reprinting of Salusbury's translation and no new translation into English. Now, almost simultaneously, both have appeared: a revised edition of Salusbury's translation published by the University of Chicago Press and the entirely new translation which is reviewed here.

Galileo, it will be remembered, vigorously espoused the new Coper-

nican doctrine that the earth rotated on its axis and revolved about the sun, and he soon became embroiled in a bitter quarrel with the reactionaries who held to the old Ptolemaic view that the earth was immobile. Forbidden by the church's decree of 1616 to teach the new doctrine, Galileo, tongue in cheek, proceeded to set forth in a book the two opposing views in dialogue form—ostensibly impartially, but actually in such a way as to present the new views in a remarkably clear and convincing fashion and to poke excellent fun at the old views. Galileo's enemies failed to see the joke, and they were powerful enough to bring about the scandalous trial for heresy which culminated in the tragic picture of an ill and frightened old man denying the very truths to which his brilliant mind had led him.

Galileo wrote the *Dialogue* not just for the scientists but also for the non-scientist reading public. He wrote not in Latin, but in colloquial Italian. His arguments were couched in non-technical language, and he drew many parallels to familiar experience by way of making his points clear. Stillman Drake in doing this new translation has made a studied effort to carry over this general effect into modern English. On the whole he has succeeded very well. Without sacrificing the dignity which must have been inherent in Galileo's original text, the translator has produced simple and direct conversational prose with just enough colloquialism here and there to add spice. Occasionally, it must be said, one wonders if the colloquialism goes too far; this reviewer feels strongly about the common misuse of the word mutual in "our mutual friend", an expression which occurs a number of times in the translation.

To many who have been fascinated by the brilliance of Galileo and his tragic story it will be a delight to read now so easily the famous conversations among the three friends: Salviati, the scientist propounding the new astronomy; Sagredo, the intelligent listener with mind open to reason; and Simplicio, the simpleton stubbornly clinging to the authoritarian pronouncements of Aristotle even as his time-honoured arguments are, one after another, crushingly refuted. Most of the time the reader will be filled with admiration, and indeed even instructed, by the beautifully clear exposition of difficult ideas. Take, for example, the passage in which Salviati explains the phenomenon of libration which Galileo had discovered and explained:

> . . . But here I happen to remember a specific event newly observed on the moon by our Academic friend, by means of which two necessary consequences may be inferred. One is that we do see somewhat more than half the moon, and the other is that the moon's motion bears an exact relation to the centre of the earth. And what he observed was as follows.

If the moon did have a natural agreement and correspondence with the earth, facing it with some very definite part, then the straight line which joins their centers would always have to pass through the same point on the surface of the moon, so that anyone looking from the center of the earth would always see the same lunar disc bounded by exactly the same circumference. But for anyone located on the earth's surface, the rays passing from his eyes to the centre of the moon's globe would not pass through that very point on its surface through which passes the line drawn from the centre of the earth to the centre of the moon, unless the latter were directly overhead. Hence when the moon is to the east or west, the point of incidence of the visual rays is above that of the line connecting the centers, and therefore some part of the edge of the moon's hemisphere is revealed and a similar section hidden on the under side; I mean "revealed" and "hidden" with respect to that hemisphere which would be seen from the exact center of the earth. And since that part of the moon's circumference which is on top at rising is underneath at setting, the difference in appearance of these upper and lower parts ought to be noticeable enough because of various spots or markings on those parts being observable also at the northern and southern extremities of the same disc, according as the moon is at its most southerly or most northerly point along the meridian. When it is northerly, some of its northern parts are hidden and the southern revealed, and vice versa.

Now the telescope has made it certain that this conclusion is in fact verified. For there are two special markings on the moon, one of which is seen to the northwest when the moon is on the meridian, and the other almost diametrically opposite. The former is visible even without a telescope, but not the latter. The one toward the northwest is a small oval spot separated from three larger ones. The opposite one is smaller, and likewise stands apart from larger marks in a sufficiently clear field. In both of these the variation mentioned already is quite clearly observed; they are seen opposite to one another, now close to the edge of the lunar disc and now farther away. The difference is such that the distance between the northwesterly spot and the edge of the disc is at one time more than twice what it is at another. As to the other spot, being much closer to the edge of the disc, the change is more than threefold from one time to the other. From which it is obvious that the moon, as if drawn by a magnetic force, faces the earth constantly with one surface and never deviates in this regard.

On the other hand, Galileo is not always right, and from time to time his fallibility points up the self-righteous trait in his nature which so infuriated those who were the objects of his scorn. Thus, Salviati, speaking of Kepler's lunar theory of the tides says:

. . . But among all the great men who have philosophized about this remarkable effect, I am more than astonished at Kepler than at any other. Despite his open and acute mind, and though he has at his fingertips the motions attributed to the earth, he has nevertheless lent his ear and his assent to the moon's dominion over the waters, to occult properties, and to such puerilities.

It so happens that in tidal theory Kepler was much nearer the truth than was Galileo.

The new edition of the *Dialogue* is beautifully done. Included are Galileo's marginal summaries, the notes added by him after publication, twenty-five pages of interesting and instructive notes by the translator and a reasonably complete index. In a foreword Albert Einstein discusses the cultural and philosophical significance of the *Dialogue*, and in a preface the translator gives a brief account of Galileo's life.

J. F. H.

Laboratory Instruments, Their Design and Application, by Elliott and Dickson. Pages 414; 8⅝ x 5½ in. New York, The Chemical Publishing Co., Inc., 1953. Price $7.50.

The research worker is often called upon to devise and construct his own instruments, and finds his training inadequate to cover the many ramifications involved. This book will serve as a guide to those engaged in research. Those who make a hobby of building telescopes and other instruments will also find the book very helpful.

The early chapters deal with the properties of various materials, and their treatment and use in the construction of instruments. There is a chapter on the preparation of drawings for workshop use and their reproduction. Succeeding chapters are on methods of construction,—geometric design, vibration insulation, sensitivity, and methods of measurement.

Of astronomical interest are the chapters on the uses and working of glass, followed by a description of a number of optical instruments and devices. The final chapter is on the applications of photography.

W. R. H.

Schwerkraft und Weltall by Pascual Jordan. Series Die Wissenschaft, Band 107. Pages viii plus 208; 5¾ x 8¼ in. Braunschweig, Friedr. Vieweg und Sohn, 1952. Price DM 15.80.

Among the large number of text-books on cosmology we find either a very popular description only or a highly mathematical treatment of a special cosmological problem. The present work is a text-book on the mathematical principles of the general theory of relativity, followed by a study on five-dimensional projective theory of relativity.

The chapters are as follows: geometry, gravitation, the projective theory of relativity and application to four dimensions.

Chapter I deals with the elements of the Riemanian geometry and with operations on vectors and tensors. The difference between the Euclidean and Riemanian geometry is characterized by the presence of a non-zero tensor of curvature in the last, which plays an essential role in the general theory of relativity.

In chapter II the equations of a gravitational field are derived by analogy to the Poisson equation of Newton's theory. From these the formulae of three Einstein effects follow in a simple way. Application to different cosmological models fixes the age of the universe at from 1.3 to 1.9 thousand million years, while, in geological scale, its age must be at least twice as much. Einstein, Lamaître, and others have tried to escape the difficulty by introducing a "cosmological term" in the equations. On the basis of subsequent investigation Jordan has rejected the idea of the cosmological term and has shown that a variable Einstein's "constant", κ, would bring the models to a closer agreement with the present state of the universe.

Chapter III is highly mathematical but it is not essential to the understanding of the following chapter. It deals with a group of invariant projectors in five dimensions. Five-dimensional tensors are called projectors here. It is shown that Einstein's constant of gravitation, $\kappa = Jc^2/2C^2$, is a function of an invariant, J, of the five-dimensional metrics. In chapter II this J was assumed to be constant, and equal to one.

If the postulates of this chapter are applied to the equations of chapter II, they can be rewritten in a slightly different form. This has been done in Chapter IV. Although it is not possible, with the present knowledge of the universe, to prove the assumption of a variable κ, the author has discussed three arguments in favour of this. They are the origin of double stars and of planets and the evolution of the earth's crust. Jordan has shown that one can explain the present distribution of distances of double stars and planets only, if the value of κ has diminished by a factor of 20 since the time of their creation. To the last argument the author quotes the ideas of Fisher as follows: The original earth crust was as large as the surface of the earth. Due to a diminution of κ the radius of the earth had to become larger (to make $\kappa^2 M$ constant). The expansion of the radius could then be the cause of the disintegration of the crust into continents.

To those who read German one can recommend this interesting book with its bold, new ideas. In the author's opinion, expressed in the foreword, this book may help to find new friends among the physicists for the general theory of relativity. This aim has undoubtedly been achieved.

G. A. B.

NOTES AND QUERIES

Upsilon Sagittarii

Upsilon Sagittarii is a spectroscopic binary with a period of 138 days. The brighter component is a B8 supergiant with very strong helium and metallic lines. It is about 100 times the size of the sun, and 50,000 times as luminous. The fainter component can be detected only through the light variations of the pair. Dr. Dean B. McLaughlin has studied one peculiarity of the spectrum, the "satellites" that accompany the hydrogen lines. These are always shifted to the violet of the normal position suggesting that they are caused by the absorption of gas approaching the observer. Since they are visible only during that half of each period when the fainter star is the nearest to the earth, they must be produced by the light of the bright star shining through a very extensive, expanding atmosphere surrounding the fainter star. In order for this effect to be noticeable for such a long duration, the gaseous envelope must extend outward from the faint star far enough to involve the bright star. The satellites do not always appear when expected. Dr. McLaughlin suggests this would be explained if the faint star were intermittently ejecting hydrogen clouds. This type of phenomenon is characteristic of the star P Cygni. The eruption of hydrogen is spasmodic, since there are times when double satellite lines appear in the spectrum.

B. R. G.

Tides in the Atmosphere

Although the tides in the ocean are well know and readily observed, the tides in the atmosphere are not very apparent, and are masked by the effects of the sun on the atmosphere. In fact, it requires infinitely careful measurements to detect the tides in the atmosphere. This problem is discussed by Sydney Chapman in the May 1954 issue of *Scientific American*. Mr. Chapman has done considerable work in this field.

Sir Isaac Newton was the first to suggest that there should be tides in the atmosphere, but he decided that they would be undetectable. However, from careful analyses of barometric measurements the atmospheric tides have been detected. High and low tide in the atmosphere correspond to higher and lower barometric pressure.

Over a century ago, the great French mathematician Laplace made the first really systematic attempt to detect the atmospheric tides. He computed that the lunar tides should cause a daily rise and fall in the

barometer of one quarter of a millimetre of mercury near the equator, and less in other latitudes. However, he failed to detect any significant effect attributable to the moon when he analyzed almost 5000 daily barometric observations stretched over eight years taken at the Paris Observatory. Later investigators also failed, though one had 30,000 readings available for analysis.

The difficulty in detecting the lunar effect is brought about by the lunar tides in the atmosphere being obscured by the sun's tidal force and daily heating of the atmosphere, and irregular fluctuations in the air which are most evident in higher latitudes.

It appears that in the formation of the atmospheric tides the effect of the sun is greater than that of the moon, in contrast to the ocean tides in which the moon has the greater effect. The reason is that the atmosphere has a natural period of vibration which is very nearly the same as the sun's period of 12 hours, and the resonance makes the vibration greater. Resonance also amplifies air waves caused by the heat of the sun—again a 12-hour period. Other unknown factors also contribute.

In order to isolate the effect of the lunar tide, long series of barometric pressure observations covering almost fifteen years must be analysed in such a way that the part caused by the sun and the irregular variations are cancelled out. This was first accomplished by John Henry Lefroy in 1842, using observations from a station in the tropics where the irregular effects were small. The lunar tide was found to cause regular changes in atmospheric pressure amounting to about a tenth of a millimetre of mercury. The first time the lunar tide was found from observations outside the tropics was in 1918 when Chapman analysed observations covering 64 years taken at the Greenwich Observatory; here the rhythmic change in pressure was less than a hundredth of a millimetre of mercury. It is small wonder that it was hard to find.

By now the amount of the lunar tide has been found at more than sixty places over the earth. There is no great variation from place to place as there is with the ocean tide: there are no "shores" in the atmosphere. However, the effect of the chain of the Rocky Mountains is detectable. An unexpected result is that the daily high lunar atmospheric tides come an hour or two later in January and February than they do in May and June.

Recently another method of detecting the lunar atmospheric tide has been developed: the height of the ionosphere can be found by timing radar signals reflected from it. In this way it is possible to follow the double wave of the atmospheric tide as it goes around the earth.

R. J. N.

OBSERVATIONS OF PLANETS AT PIC DU MIDI

The German language monthly "Notes to the Observers of Planets" (*Mitteilungen fur Planetenbeobachter*, vol. 6, no. 5 and 6) has a very interesting account of the visual and photographic observations of planets at the French high-altitude observatory at Pic du Midi.

In the first part are mentioned the difficulties which Lyot and his co-workers had to overcome in order to get their 60-cm. objective as close as possible to the limiting resolving power of 0.20 second of arc.

The second part contains quite surprising results. The planet Mercury which was continually under observation by Lyot during one half of its revolution, showed a number of configurations identical with those mapped by Schiaparelli. Because the time elapsed between the two sets of observations contained 220 revolutions, Lyot concluded that the rotation and the revolution of Mercury are identical to 1/10,000 of their length. The latitude was different by 15 degrees which means that the equator must be inclined by 7.5 degrees to the orbital plane. If there is an atmosphere around Mercury, its density cannot surpass 1/300 of that on earth.

For the first time the people at Pic du Midi have observed spots on Venus. However, more observations are needed before any conclusions can be drawn about the time of rotation, the inclination of the orbit and the composition of the atmosphere.

Jupiter showed a change in the position of the bands. A study of the four biggest satellites has been undertaken and a map of their surfaces is near completion. It is possible that the satellite III (Ganymede) has a ring like Saturn.

The other planets are being observed but at this time not many details are known.

G. A. B.

MICHAEL STEPHANOVITCH KOVALENKO, 1888–1954

Michael Kovalenko passed away on April 2, 1954, in Stamford, Connecticut, at the age of 65.

Born in Taganrog, Russia, he received degrees at the St. Petersburg Institute of Technology in 1912, and at the University of Paris in 1924. From 1924 to 1926 he participated in the research work of the McCormick Observatory at the University of Virginia. He obtained his doctorate at Princeton University in 1927, after which he held the position of Assistant Professor of Mathematics and Astronomy at Swarthmore College from 1927 until his retirement in 1939. He was engaged in research at the Sproul Observatory of Swarthmore College, and published several papers on parallaxes, mass-ratios, and proper motions.

In 1946 he established the Jessie Stevenson Kovalenko Scholarship for astronomy students or graduates of Swarthmore College. This was one of the many memorial funds he established in memory of his wife, who died in 1943.

PETER VAN DE KAMP

MONTREAL CENTRE OBSERVATORY FUND

The Montreal Centre has been given the use of a building near Douglas Hall by McGill University. This building has space for a meeting place, library, workshop and observatory. However, the building requires alterations so that it can house the Centre's six-inch refractor, and a fund has been started to finance the work. Donations to the Observatory Fund are being collected by Mr. C. Yarnell, 2290 Girouard Ave., Montreal 28.

The Montreal Centre is far ahead of the other centres in the organization of observing programmes. Their results will be even more spectacular when they have a permanently-mounted telescope always ready for work. We wish them success in this project.

THE EDITORS

CORRECTION TO PRICE OF ASTRONOMISCHER JAHRESBERICHT

The price of the *Astronomischer Jahresbericht*, volume 50, quoted in this JOURNAL, vol. 48, p. 28, 1954, should read "DM50", *not* "DM750". The Astronomische Rechen-Institut announce that volume 51 is now printed. The price will again be DM 50.

THE EDITORS

NOTES FROM OBSERVATORIES

Dominion Astrophysical Observatory, Victoria, B.C.

Eclipse Expedition. The expedition from the Dominion Astrophysical Observatory to observe the total solar eclipse of June 30 was made up of three men; Dr. K. O. Wright and Mr. P. E. Argyle from Victoria were joined at the eclipse site, Hansen, Ontario, by Mr. John Galt of the University of Toronto. The aim of the expedition was to obtain slitless spectrograms of the flash spectrum in the ten seconds immediately preceding totality and the ten seconds immediately following totality. A special spectrograph was constructed at Victoria for the observations, the essential parts being a 15,000 lines per inch grating which was used in the second order, a quartz glass camera lens of 72-inch focal length, and a mechanism at the plate holder end that moved the plate along in jumps about once a second.

Stellar Spectrograph. A further form of the new Victoria stellar spectrograph has recently been put into operation. It is a quartz single-prism spectrograph, which gives a dispersion of 40 A./mm. at λ3400. The tests of this instrument indicate that it has an excellent field and, of course, a very high transmission in the ultra-violet.

Staff. Two of the astronomers who have been absent for some time are expected to return in the near future. Jean K. McDonald who has been at the University of Toronto will probably return to Victoria in July. Before doing so, she will attend the June meeting of the American Astronomical Society in Ann Arbor, and take part in a symposium on the use of the electronic computers for the solution of astronomical problems, the symposium being a joint one between the American Astronomical Society and the Association for Computing Machinery. G. J. Odgers, who has been in Berkeley, is also expected to return to the Observatory in July.

The seasonal appointees at the Observatory for the current year are:

Dr. A. H. Joy, Mount Wilson and Palomar Observatories
Professor J. B. Warren, Department of Physics, University of British Columbia
Professor J. L. Climenhaga, Department of Physics, Victoria College
Mr. L. V. Wallace, from the University of Western Ontario, London
Mr. J. N. Merner, from the University of British Columbia
Mr. J. D. Francis, from Victoria College

These men will be employed on a variety of researches, upon which reports will appear in due course.

Professor H. Bondi of Cambridge University was a visitor at the Observatory in April. During his two-day visit he gave four excellent lectures on subjects embracing stellar structure, theory of accretion, and recent trends in cosmology. Two of the lectures were at the Observatory, the third to the student body at Victoria College, and the fourth to the Victoria Centre of the Royal Astronomical Society of Canada.

MEETINGS OF THE SOCIETY

AT EDMONTON

January 8, 1953—The meeting was called to order at 8:20 p.m. in Room 142 of the Arts Building, by the newly elected president, Mr. H. M. Burt. The minutes of the previous meeting were read and approved.

The HANDBOOK talk was given by Dr. Campbell, under the difficulty of having no new one to use. He suggested watching for the fine display when Venus and Jupiter came close together in the sky.

A report of last summer's meteor observations was given by Earl Milton, who also made an appeal for more observers to help in various fields, which he outlined. News items were given by Mr. Keeping, who summarized some of the activities of the Montreal Centre.

The main paper of the evening was by Mr. L. E. Gads of the Faculty of Engineering, who gave an outline of the life of "M. V. Lomonosoff", and an evaluation of his work in various fields of activity. Many political changes during his lifetime in Russia were a factor in keeping his name relatively unknown in the rest of the world. Before his death, however, he was acclaimed in his own country as a poet, an artist in mosaic, a geographer and geologist. He made significant contributions to astronomy, physics and physical chemistry, and is perhaps best known for the latter. An account of his work given in a presidential address to the American Chemical Society in 1912 was quoted as factual and reliable. This was compared with several rather more lurid accounts written under the aegis of the present regime in Russia.

There was a lively question and discussion period after which the meeting adjourned for the usual welcome refreshments provided by the social hostesses. There were 37 members and visitors present.

February 12, 1953—The meeting was called to order by the President at 8:20 p.m., and minutes of the previous meeting were read and approved. It was noted that the 1953 HANDBOOKS had now arrived, except for a few people who reported to the President that they had not received their copy.

Mr. Keeping gave a few extracts from news items and referred to preparations in

Montreal for observing the lunar eclipse and the conjunction of Venus and Mars. Some occultations had also been recorded with a period of cloudy weather.

The HANDBOOK talk was given as usual by Dr. Campbell who remarked that the new HANDBOOK now contained sunrise and sunset tables for lat. 54, 52 being left out to make room for it.

The main paper was given by Dr. Grayson-Smith on the subject, "Planetary Atmospheres". A lot of new information has become available in the last five years, mainly through the work of four people, Kuiper, Herzberg, Dollfus and Urey. An extended study of far infra-red spectra has been made by Kuiper and comparisons of these with laboratory spectra have been made by Herzberg. This work makes possible definite figures about the various atmospheres which can be given as centimetre-thickness reduced to the surface pressure of the earth. These figures were shown on a table put on the blackboard. On the basis of this work it can be definitely stated that the polar caps of Mars are ice from water and not carbon dioxide.

Dollfus has devised a method of measuring polarization of the light from the centre and the edge by the dark border of a planet at or near quadrature. Light from the edge is partly scattered if there is an atmosphere and thus the red and blue polarization is different for the centre and this edge. A definite figure for the atmosphere of Mars was therefore available in the table. This method implies that the clouds on Venus will be dust since there is no water and there must be great winds. Mars has very little oxygen and its atmosphere is probably largely nitrogen. All the major planets have large amounts of hydrogen in their atmosphere.

Urey, on chemical grounds, suggests a way by which particles of the inner planets could have been "cemented" by water, the larger outer planets cemented by methane, thus giving reasonable mechanisms by which they could have been formed. In the region of space between these no cementing action seems reasonable, thus no planet would be formed and this is where we now find the asteroids.

All this work suggests stages through which a planet's atmosphere would develop, particularly applied to the inner ones. *First*: there is condensed water and ammonia and hydrocarbons, leading to a methane atmosphere. *Second*: the seas form by the release of water from the rocks and dissolve carbon compounds. This will leave water vapour, ammonia and some methane in the atmosphere. Applied to the earth this carbon and water could have led to anaerobic life about two billion years ago. *Third*: water and ammonia are dissociated by sunlight and hydrogen escaping. Oxygen and nitrogen accumulate in the atmosphere and then later carbon dioxide begins to accumulate. The earth is at present in this stage. *Fourth*: in this stage the hydrogen is all gone which means no ammonia and no water. This is the stage Venus has now reached.

This work of Urey's leads us to the idea that Venus might have had some life about a billion years ago, but that this is now extinct.

There were some questions and discussion at the end of the paper and the meeting adjourned for the usual refreshments.

There were 31 members and visitors present.

March 12, 1953—The meeting was called to order at 8:20 p.m. by the President.

A report was given by Earl Milton on meteor work. He read part of a letter from Meanook Observatory and announced that special observing meetings were to be held at the Observatory starting the following Thursday.

The HANDBOOK talk was given by Dr. Campbell.

Mr. Keeping summarized an article from the British magazine *Weather* giving some details of studies on scintillation of stars using a photo-multiplier cell. The maximum effect seems to be obtained with an aperture of about 3 inches and the effective layer seems to be about 8000 feet above the surface of the earth.

The main paper of the evening was given by Dr. G. K. Horton on "The Origin of the Solar System". He showed on a blackboard a scheme with distances from the sun to the planets given in light-minutes. These varied from 0.3 for Mercury to 370 for Pluto. One important fact which needs explanation is that the sun is thousands of times the mass of Jupiter and consequently much greater than the total mass of all the planets. The rigid nebula hypothesis was first given about 1850 and Jeans criticized this severely about 1900. Various tidal hypotheses have been proposed by Moulton and others. In all these a certain vorticity theorem is not satisfied but a collision might have occurred. The temperatures involved however would dissipate the matter as vapour. A binary star collision can explain mass distribution or the angular momentum of our solar system, but not both.

Several disk theories are recent and somewhat promising. These postulate viscous non-rigid disk with angular velocity, about what the planets now have. Great eddies in these might form planets but a theorem of Rayleigh's is contradicted. It might be possible for proto-planets to form and then lose mass to the sun, but the angular momentum does not come correct here either.

How do we explain the moon? It might break off from a rotating ellipsoid of revolution becoming pear-shaped but this cannot completely explain the earth-moon system or a binary star. We might explain the asteroids as growing by accretion suggesting the vapour pressure of their surroundings being greater than at their surfaces.

Any theory should explain the constitution of the planets. It may be suggested that the cores are not iron, but rocks under high pressure and in a metallic state. Ramsay suggested that mass and density increase together but special studies of mercury do not support the idea. No theory has yet been satisfactory in answering these questions: (i) How would a disk be formed? (ii) What is the disk's behaviour? (iii) How can matter condense into planets because the force of gravity does not seem to be sufficient?

At the conclusion of the paper there were many points for discussion and several questions asked the speaker. There were 36 members and visitors present.

April 9, 1953—The meeting was called to order at 8:20 p.m. by the Vice-President, Dr. Grayson-Smith.

The HANDBOOK talk was given by Dr. Campbell.

Montreal reports few or no sun-spots found by observers in February, however a good number of aurorae were seen in Edmonton.

The main paper of the evening was given by Miss Eileen Kennedy on "White Dwarfs". Hertzsprung and Russell classified stars into giants and dwarfs. Luminosity depends on size and surface temperature. Temperature is measured by analysing light with spectroscope and measuring relative energies in various colours and wavelengths. Classes of stars are based on properties of observed spectral lines. In absolute magnitude–spectral class diagram, the white dwarfs are hot, but are faint, and hence must be small in size.

Sirius B, the first white dwarf discovered, is 10 magnitudes fainter than Sirius A, i.e., 10,000 times less bright. Its density is 65,000 times that of water.

Eddington suggested the explanation of stripping electron shells from atoms, thus allowing the nuclei which contain most of the mass to be crowded together. This degenerate matter can explain the extreme density. White dwarfs at one time were thought to be rare but it is now known that there are many.

There are still points to be settled in the physical theories which govern the behaviour of matter in this degenerate state, and there were many references to this during the question period which followed the conclusion of the paper. There were 22 members and visitors present.

May 21, 1953—The meeting was called to order by the President at 8:20 p.m. in the Arts Building. The minutes of the previous meeting were read and approved.

The Handbook talk: Dr. Campbell gave an explanation of the appearance of Venus in the sky when it changes from a bright evening star to a bright morning star, including reasons why this takes place much more rapidly than when the change is from morning to evening star.

The main part of the programme consisted of "An appreciation of the work of Cyril Wates" and was given very close to the tenth anniversary of the official opening of the Wates Telescope.

The first speaker was Mr. Keeping, who reviewed some of the qualities of Mr. Wates as a man, pointing out his wide interest in astronomy, photography and mountaineering, as well as his ability to give clear explanations of any subject in which he prepared an address.

The second speaker was E. H. Gowan, who gave a short outline of the principles of "Optics", which are the basis of all telescopes. He included a short description of the types of mounting with particular reference to the one which had been adopted by Mr. Wates for his 12½-inch telescope. In conclusion he gave some description of the way in which this mounting was actually constructed in the observatory and how the final adjustments would be made to get the polar axis accurately in place.

The third speaker, Dr. J. W. Campbell gave a short explanation of the way in which timing devices are attached to telescopes in order to allow the line of sight of the telescope to follow a star. This is done by producing a motion of the telescope which exactly counteracts the motion of the earth on its axis.

Following these papers the audience adjourned to the Observatory where actual demonstrations were given of the motion of the telescope and its controls and a short period of observing was available as well.

The meeting concluded with the serving of refreshments in the Drill Hall. There were sixteen members and visitors present.

October 8, 1953—The meeting was called to order by the President at 8:20 p.m.

Frank Lodie told about the summer observing programme, noting observation of 65 aurorae, 159 spots on the sun with a telescope, 9 with the naked eye. 43 Perseid meteors were observed in three hours. Observations were also made of the partial eclipse of the sun and of the eclipse of the moon.

The HANDBOOK talk was given by Dr. Campbell. The main paper was given by Earl Milton, on the subject "Our Cosmic Neighbours". These neighbours of ours are mainly members of the solar system and a general survey of them was given, including a very instructive scale showing their sizes and distances. Each member of the solar family was then discussed in more detail. The general class of asteroids, comets and meteors were mentioned too, as interesting in themselves, and perhaps worthy of more detailed treatment later. The aurora was mentioned briefly in a side note.

After some questions and discussion, including compliments on the presentation of Earl Milton's first major paper, the meeting adjourned for refreshments. There were 21 members and visitors present.

October 29, 1953—Regular meeting. The meeting was called to order by the President at 8:20. p.m.

After announcing the date and place of the annual dinner meeting the President appointed Dr. Campbell, Mr. Williams and Mr. Phibbs to act as nominating committee and Mr. Stockwell to act as auditor.

The HANDBOOK talk was given by Dr. Campbell.

The main paper of the evening, was given by Dr. P. M. Millman, of the Dominion Observatory, Ottawa. Dr. Millman recently made an extended trip to the southwestern part of this continent, visiting many places of astronomical interest. His address, called "An Astronomical Pilgrimage" was illustrated by his own beautiful colour pictures.

The points of interest visited and illustrated included the great Arizona meteor crater, and the Observatory at Flagstaff. Four Schmidt meteor cameras in New Mexico are co-operating with the two in Alberta in observations designed to give information on the density of the upper atmosphere. An account was given of three other visits; to Palomar, Mount Wilson and the Lick observatories. In several places Dr. Millman's camera caught cacti and birds in repose and motion, representing the extent of his intense interest in the natural world.

During the discussion period some of the staff of the Meanook observatory were introduced, and at the conclusion an enjoyable half hour was spent over the refreshments. There were 35 members and visitors present.

December 3, 1953—The meeting was called to order at 8:00 p.m. after dinner in the Banquet Room of the Corona Hotel.

The HANDBOOK talk was given by Dr. Campbell.

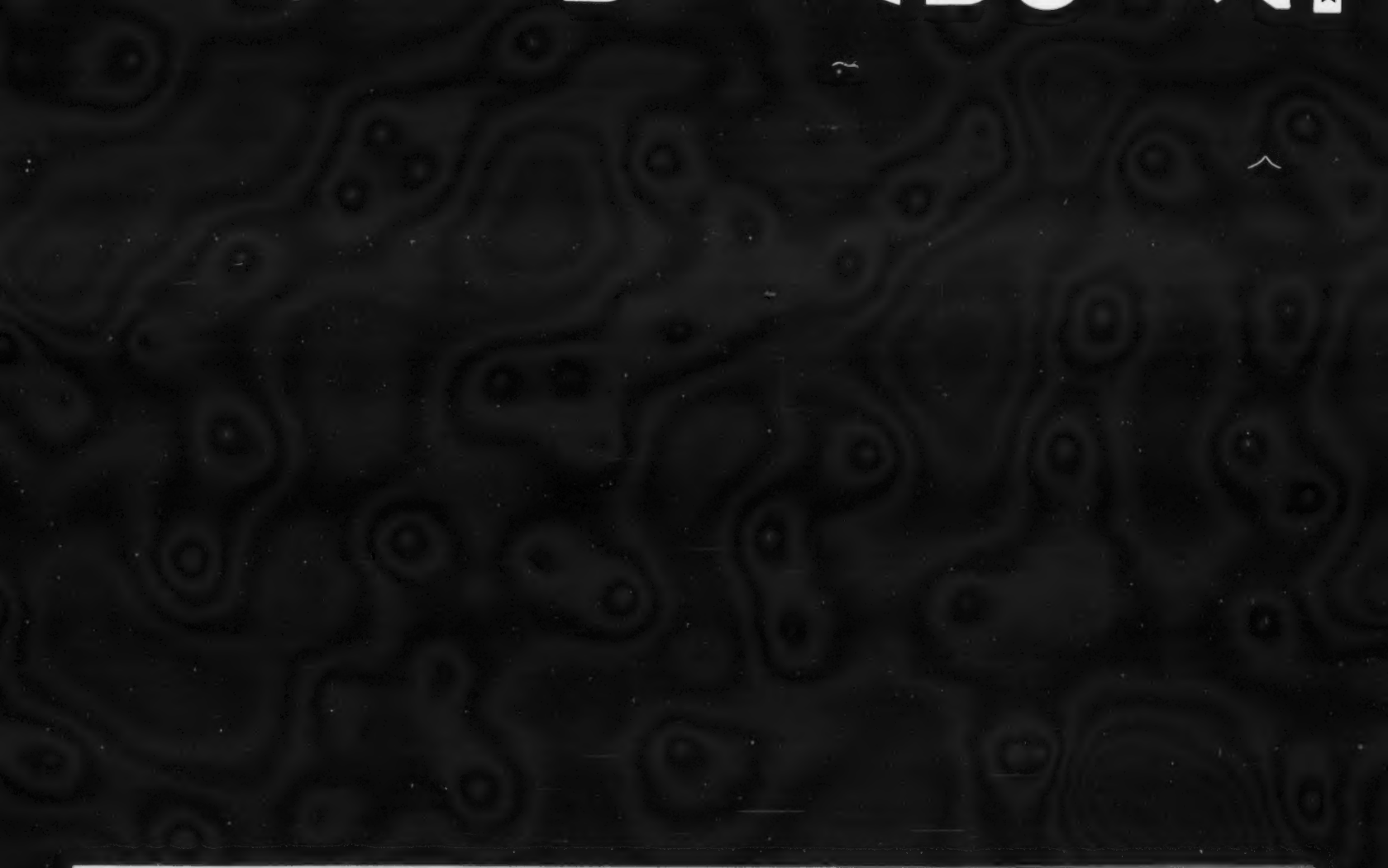
Report on observing activities by Earl Milton. Scores for sun-spots, aurorae and meteors were reported, also an account of eclipse observations. Much observing was interfered with by clouds. Two short glimpses of the planet Mercury crossing the sun were obtained through the clouds.

The Observatory report was given by Dr. Campbell. There has been good public response, but some cold nights interfered. There is good co-operation from newspaper and radio stations in announcing at short notice when the observatory will be open. Reports were made by the Librarian, Treasurer, Secretary and Nominating Committee. The election of officers followed.

The main address was given by Professor L. E. Gads, of the Department of Civil Engineering, in which he gave an account of various "Astronomical Visits" he made recently. These included two planetaria, the one at New York and one in Hollywood, and he gave a description of the entertainment provided in each. As a "visiting fireman" he was given every opportunity to talk to the lecturers afterwards and to examine the operation of the equipment and the organization of the "show". The description continued with an account of a visit to Palomar Mountain and some history of the development of that great observatory. The comments, humorous and otherwise, and the very interesting pictures, were much appreciated by the audience.

After some questions and discussion the meeting adjourned. There were 38 members and visitors present.

E. H. GOWAN, *Secretary*.



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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XLVIII, No. 4 JULY–AUGUST, 1954 WHOLE No. 409

Articles PAGE

Where to Draw the Line ..... *Warren D. Forrester* 129

Swarthmore Conference on Astronomical Research in Colleges ..... *Ruth J. Northcott* 134

Variations of the Daily Level of the 10.7-centimetre Solar Emission ..... *A. E. Covington* and *W. J. Medd* 136

Variable Star Notes ..... *Margaret W. Mayall* 150

Review of Publications

Dialogue Concerning the Two Chief World Systems by Galileo Galilei (*J.F.H.*); Laboratory Instruments, Their Design and Application by Elliot and Dickson (*W.R.H.*); Schwerkraft und Weltall by Pascual Jordan (*G.A.B.*) 154

Notes and Queries

Upsilon Sagittarii (*B.R.G.*); Tides in the Atmosphere (*R.J.N.*); Observations of Planets at Pic du Midi (*G.A.B.*); Michael Stephanovitch Kovalenko, 1888–1954 (*Peter van de Kamp*); Montreal Centre Observatory Fund; Correction to Price of Astronomischer Jahresbericht 159

Notes from Observatories

Dominion Astrophysical Observatory, Victoria, B.C. 163

Meetings of the Society

At Edmonton 164

Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

Business correspondence and remittances should be addressed to J. H. Horning, Treasurer of the Society, 13 Ross Street, Toronto 2B.
$3.00 per annum, Single number, 50 cents.
Subscription to the JOURNAL is included in membership fee.